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GUMBOTIL AS A POTENTIAL SOURCE OF ROTARY DRILLING MUD, BONDING CLAY AND BLEACHING CLAY

A Progress Report on the Study of Illinois Surficial Clays

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INTRODUCTION

The Illinois Geological Survey is investigating the surficial clays of the State with respect to their use for rotary drilling mud, bonding clay and bleaching clay. Materials suitable for drilling mud, bonding clay and oil decolorizing clay are actively being sought. As the clay minerals comprising a natural clay are in a large measure responsible for its suitability for any of the above uses, special attention has been given in the preliminary stages of this study to mineral composition (see p. 4) as the basis for differentiating between unpromising clays and those having promise and therefore worthy of further tests.

The study of surficial clays, though but well started, has revealed that a weathered glacial clay, gumbotil, offers good possibilities as a source of clay for the uses mentioned above. The most promising sample gave results which approach those for bentonite, a clay which is widely used for these purposes.

General studies of gumbotil indicate that its constitution varies from place to place both as to the amount of sand and silt present and the amount and character of the clay minerals present. Therefore not all occurrences of the gumbotil will be satisfactory. Rather each deposit must be tested individually and its own peculiar qualities given consideration.

As gumbotil is commonly silty and sandy it would usually require processing to remove these non-clay materials to provide a product generally suitable for commercial purposes. However, because of the price commanded by clay suitable for many nonceramic uses, it is believed that this is probably not an obstacle to the economic utilization of the superior gumbotils.

In view of the greatly enlarged oil activity in the State requiring large quantities of drilling mud, it is felt timely and desirable to present a progress report on certain of the results at hand, despite the incompleteness of the study. It is hoped that as this research progresses other types of useful materials will be found and fairly complete information will be gained regarding the value of the different types of surficial clays.

SAMPLE B-18

Source

The exposure is located on the north side of the east-west road and on the east side of a creek, named Panther Creek on some maps, SE. cor. SW. 1/4 NE. 1/4 sec. 35, T. 5 N., R. 6 E., Clay County about 4 miles north of Louisville. The materials exposed are as follows:

	Thickness Ft.	in.
Probably loessial material:		
5. Soil		6
4. Silt, hard, brown and gray	1	0
Glacial drift:		
3. Gumbotil, gray and brown, contains gypsum crystals	2	6
2. Gumbo sand, brown, noncalcareous	1	6
1. Silt, gray, slightly calcareous	1	0
Covered		

Sample B-18 was taken from bed 3.

No tests were made on the materials in beds 4 and 2 but it would doubtless be desirable to investigate the possibility that the clay fraction of these materials might have value.

Two feet or more of gumbotil was also observed in cuts along the east-west road as far west (0.7 mi.) as U. S. Route 45. Judging from these cuts it appears that prospecting may reveal large areas of flat upland underlain by 2 to 3 feet of gumbotil under 3 to 5 feet of overburden.

Results of tests

Clay mineralogy. - There are three common groups of clay minerals found in the surficial clays of Illinois; namely illite, kaolinite and montmorillonite. Of these three clay mineral groups, it is known that minerals of the montmorillonite group possess properties which are likely to give to clays containing a sufficient amount of this group of minerals, mud-making, bleaching and bonding properties. Some of the minerals of the illite group likewise possess similar characteristics though usually to a lesser degree. The identity of the clay minerals in a clay is therefore a convenient means of distinguishing between clays likely to have value for all these purposes and those clays which are unpromising.

The results of clay mineral studies of sample B-18 show that its clay fraction is composed of montmorillonite, illite and kaolinite in that order of abundance.

Particle size. - In most clays used for mud-making, bleaching and bonding, the clay minerals present are solely responsible for the desirable properties of the clays. It is important, therefore, to know the amount of this material present. It has been found in general that that portion of a natural clay consisting of particles smaller than 0.002 mm is composed very largely of clay mineral material whereas the coarser material is mainly quartz and other nonclay mineral materials. Particle size determinations on sample B-18 gave the following results:

	Per cent
Clay fraction, -0.002 mm	28.8
Silt fraction, 0.002 to 0.053 mm (270 mesh)	40.6
Sand and pebbles, +0.053 mm (270 mesh)	30.6

Rotary mud-making tests, Pure Oil Co. - Through the courtesy of Mr. R. W. McIlvain, Jr., Division Manager, Illinois Producing Division, Pure Oil Company, Olney, Illinois, and Mr. I. W. Alcorn, Division Production Engineer, Pure Oil Company, Houston, Texas, tests were made in the company's laboratories of sample B-18 not further identified. The material tested was the clay fraction only, that is, the minus 0.002 mm material, a refined clay, which was obtained by sedimentation from the original raw gumbotil. The results of the tests made by the Pure Oil Company are quoted below:

REPORT ON CLAY SAMPLE NUMBERED B-18 TO
DETERMINE ITS SUITABILITY FOR USE IN
ROTARY DRILLING FLUIDS

Sample Submitted By:

Illinois State Geological Survey Division

INTRODUCTION

The sample, as received, appeared to have been refined in such a manner as to remove all sand and foreign materials. Further preparation of the sample for testing consisted of drying and grinding to pass 200 mesh. The mud fluid was prepared by using a given volume of distilled water and weights of dried and ground clay. These various mixtures of clay and water were hydrated and agitated in a Hamilton Beach drink mixer for fifteen minutes. Viscosities were obtained by Stormer Viscosimeter with spindle rotating at 600 rpm. Initial viscosity was taken immediately upon completion of the fifteen-minute mixing period. Twenty-four hour viscosity was taken after samples had been allowed to set in sealed containers for twenty-four hours.

Immediately before taking the twenty-four hour viscosity, the sample was reagitated for about one minute in the drink mixer. Gel strengths were also taken on the Stormer instrument, using standard procedure, immediately after determining the initial viscosity. pH was determined on the Beckman pH Tester, using a 20 per cent suspension of the clays in distilled water. Specific gravity of the clays was determined by using the freshly dried and ground sample and calculated from displacement made by a weighed sample placed in the specific gravity flask. Filtration characteristics were determined on the low pressure Baroid Sales Company's Performance Tester using No. 50 Whatman Filter Paper with pressure of 100 pounds per square inch. The curves plotted from the above data also show typical curves for other standard clays used in rotary drilling fluids. The curves on "viscosity-percentage of solids" (fig. 1) are valuable not only from a comparative standpoint, but by using the "yield-barrels of mud per ton of clay" reading we can quickly determine the cost per barrel of these various muds at given viscosities, if we know the cost per ton of dry clay.

Table 1. - Test Data, Sample B-18

Specific gravity of dry clay - 2.48

pH - 20% suspension - 8.45

% of solids by weight	20%	23%	25%	27.5%
Grams of clay	100.0	115.0	125.0	137.5
Grams distilled H_2O	400.0	385.0	375.0	362.5
Initial viscosity	7.0	15.0	25.5	68.0
24-hour viscosity	11.0	No test	36.0	No test
Initial gel	0	4.0	7.0	40.0
10-minute gel	34.0	75.0	150.0	230.0
Weight/gallon	9.4	9.6	9.8	10.0

The 23 per cent sample was used to determine the effect of cement and salt water contamination. Addition of 1 per cent cement flocculated the sample into a plastic mass. Addition of salt to equivalent of sea water brine also flocculated the sample, but not as badly as the cement.

The above reactions of cement and salt water have occurred with all clays, containing appreciable amounts of colloidal material, tested to date.

The viscosity and gel of the mud was readily reduced by the ordinary viscosity breakers.

Table 2. - Filter Press Data, Sample B-18

Time of Reading (minutes)	Volume of Filtrate (cc) 20% Suspension	25% Suspension	27.5% Suspension
1	2.0	1.0	0.7
2	3.0	1.5	1.3
3	4.0	2.4	1.8
4	5.0	3.0	2.1
5	5.8	3.7	2.5
10	9.0	6.0	4.5
20	13.2	8.6	6.8
30	15.9	10.7	8.4
60	21.5	14.0	11.0
120	30.0	21.0	16.0
180	40.0	27.1	19.8
Cake thickness at 180 min.	11/32"	12/32"	10/32"

The above results may be considered very good for a natural clay other than bentonite. See figure 3 for comparison of filtrate volumes.

COMPARATIVE CURVES

(Figures 1 - 3)

The following curves include the above data on Sample B-18 along with similar data on such standard materials as Aquagel, Baroco and El Paso Clay. It will be noted that Aquagel (bentonite) rates highest in all the qualities desired in a rotary

drilling mud with the exception of weight of resulting fluid. The reason for Aquagel being high in these qualities is the high concentration of colloidal material. Its greatest use is as an admix with other clays and in native muds as a conditioner.

Baroco is a ground mixture of clay and a salt water resisting bentonite. The yield of forty barrels of 15 centipoise mud per ton is controlled in the manufacture of the ground mixture.

El Paso rotary clay is a natural clay mined at various locations near El Paso, Texas, and has long been accepted as a good low-priced clay from which it is possible to make a satisfactory ten-pound-per-gallon mud. Aquagel (bentonite) is often used along with El Paso clay to improve its sealing action.

CONCLUSION

The various tests given this clay indicate that sample B-18 should make a good rotary mud giving from 22 to 17 barrels yield per ton of dry clay at 15 to 60 centipoises and from 9.7 to 10.0 pounds per gallon. These characteristics can, of course, be varied to suit individual requirements by using admixes of weighting material and bentonite.

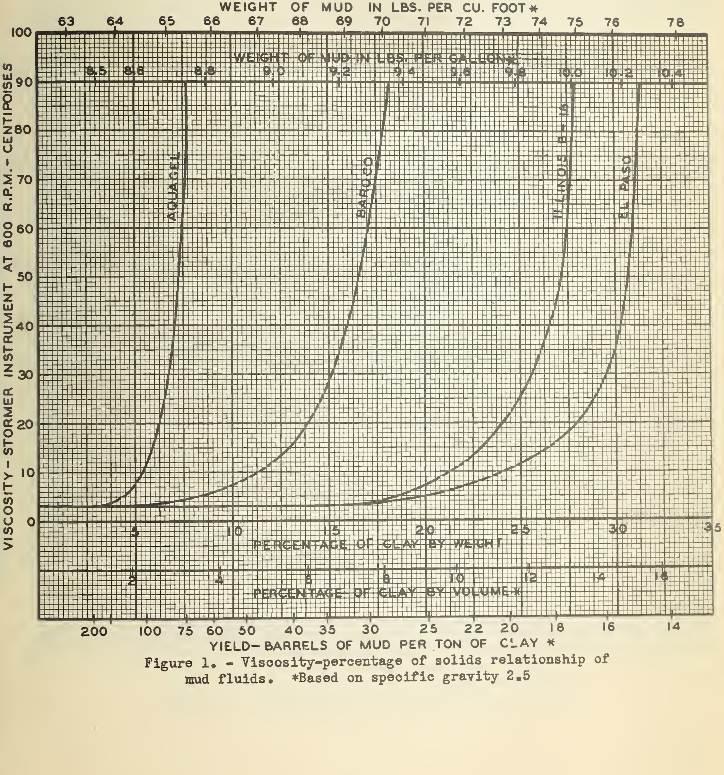

Figure 1. - Viscosity-percentage of solids relationship of mud fluids. *Based on specific gravity 2.5

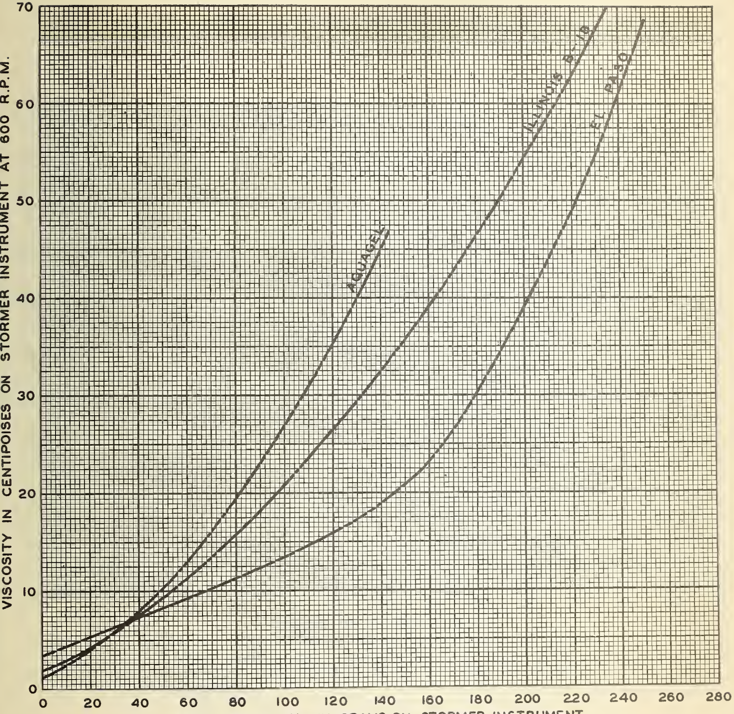

Figure 2. - Viscosity gel relationship of mud fluids.

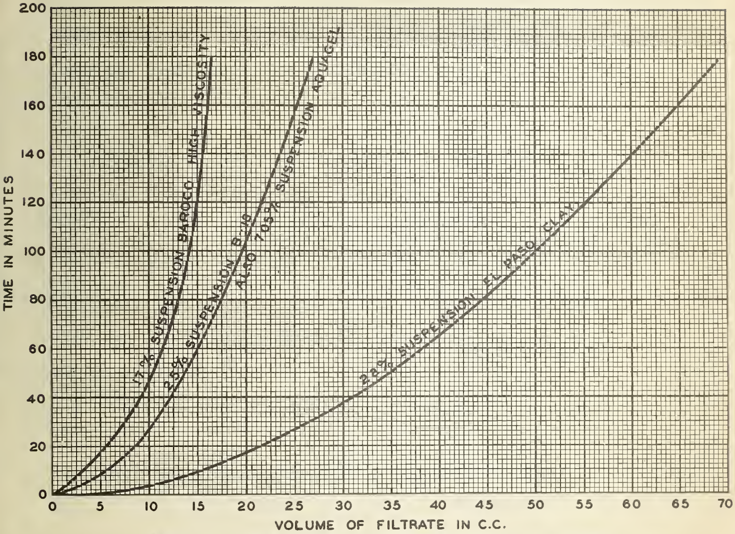

Figure 3. - Time-filtrate volume relationship for various clay suspensions. Interpretation of these curves requires consideration of the per cent solids suspension.

Rotary mud-making tests, State Geological Survey. - In the Survey laboratory viscosity determinations with the Marsh funnel were made on the refined B-18. A 9.87-pound-per-gallon mud flowed 500 cc through the funnel in 5 minutes and 45 seconds. In order to get a mud which would pass more readily through the funnel and give times comparable with that of drilling muds in use, a 9.09-pound mud was prepared. The results of the Marsh funnel tests are given in table 3.

Table 3. - Marsh Funnel Tests on Sample B-18

Sample	Mud weight (Lbs./gal.)	Initial viscosity (seconds)	Viscosity in seconds after standing 10 min.
Refined, clay fraction only (a)	9.1	48.5	50.0
De-sanded (b)	10.0	37.0	37.2
Refined, plus 43.5 g sodium oxalate per liter of mud (c)	9.3	56.5	63.6

(a) Clay grade only. Mud prepared by mixing dried, pulverized clay, and water in laboratory ball mill with inserted baffles for 8 hours.

(b) Mud prepared from clay processed to remove sand (+270 mesh). The sample tested includes therefore the clay and silt fractions of the raw gumbotil. Mixed in malted milk stirrer.

(c) The amount of sodium oxalate used was based upon the quantity required to produce optimum deflocculation, according to laboratory tests. The mud weight given is for the mud after the addition of the oxalate.

The viscosity tests of the refined mud to which sodium oxalate had been added were made to determine the probable effect of the

sodium ion on mud viscosity. The data suggest that the addition of this ion in proper amounts may increase viscosity.

<u>Bonding properties</u>. - The information at hand regarding the value of the refined B-18 clay as a bonding clay for synthetic molding sand consists of a single test, kindly made by Mr. Carl E. Schubert, Associate in Mechanical Engineering, Department of Mechanical Engineering, University of Illinois. Since this was a single test the results are to be regarded as provisional. The following description of the test is quoted from Mr. Schubert's report.

> The clay sample was mixed with standard silica sand to produce a synthetic molding sand. Three thousand grams of American Foundrymen's Association silica sand were taken and 4.6 per cent clay added to it. The clay and silica sand were mixed in a Simpson sand mixing machine for 2 minutes. To the batch was added 5 per cent water by weight. The water was added in approximately one-third amounts at one time, and clay, sand, and water mixed for about 40 seconds before the next one-third amount of water was added. This took approximately 2 minutes to add all of the water to the batch.
>
> The sand, clay and water was then allowed to mix for another 3 minutes. The total mixing time of clay and sand, and clay, sand and water was, therefore, 7 minutes. This procedure conforms with the procedure which is usually followed. After mixing the sand as above, it was then allowed to temper over night in a glass bottle with a rubber stopper. After tempering, the moisture, green

permeability and green compression strength tests were performed on the sample with the following results:

Kind of clay - - - - -	B-18 (refined)
Water (per cent) - - - - -	5.9 (a)
Green permeability - - - - -	75 to 80
Green compression (lbs./sq. in.) - - - - -	2.2

(a) The reason for the gain in moisture is not known.

The moisture in this sample was a little high and according to Mr. Schubert if it were lowered to 5 per cent, the green compression strength would probably be in the neighborhood of 3.0 pounds per square inch.

The above data are of interest when contrasted with similar data for bentonite clay which, according to Mr. Schubert, when tested as above produced 4.0 pounds green compression strength at 5 per cent water, 4.6 per cent clay and a permeability of 75 to 80.

A considerably greater variety of tests is necessary to evaluate the worth of the refined B-18 clay as a molding sand bond. However, the above data suggest that it may have possibilities for this purpose.

Bleaching properties. - A rough measure of bleaching properties was obtained from tests made according to the method outlined by Nutting[1/], whose procedure was followed exactly except that crude oil from the Robinson sand, Crawford County, Illinois, main field, about four miles west of Robinson, diluted with an equal volume of

commercial grade naphta was used in place of the Kettleman (Calif.) crude used by Nutting. This test is a percolation type of test involving the use of a constant measured volume of minus 200-mesh clay through which the oil is allowed to percolate. The results are expressed in terms of the height in test tubes of standard size of the columns of water-white, yellow, orange and red oil resulting from percolation.

Results of percolation tests on Sample B-18 are given in table 4.

Table 4. - Results of Percolation Tests on Sample B-18 a/

Sample	Condition of sample	Height of column (inches)			
		Water-white	Yellow	Orange	Red
B-18	Refined clay fraction	12/16	3/16	2/16	3/16
B-18	Raw gumbotil	10/16	1/16	1/16	1/16
Standard fuller's earth b/		10/16	2/16	3/16	2/16

a/ Tests made by Mr. Paul Henline, Research Assistant, Analytical Division of the Geochemical Section, Illinois State Geological Survey, under supervision of Dr. O. W. Rees.

b/ Standard fuller's earth as furnished by the American Oil Chemists Society.

OTHER GUMBOTIL SAMPLES

In addition to Sample B-18, three other samples of gumbotil were collected and studied in a preliminary fashion. Data on these samples are included primarily for the purpose of showing the

variations in the character of the gumbotil. Sources of samples are as follows:

Samples B-13 and B-14

The exposure is found in cut along State Highway 37, 0.9 mile west from the junction with U. S. Highway 45, cen. N. line, NE. 1/4 NW. 1/4 SW. 1/4 SW. 1/4 sec. 29, T. 7 N., R. 6 E., Effingham County.

	Thickness Ft.	in.
Probably loessial material:		
7. Silt, gray-brown, organic material at top	1	6
6. Clay, gray and dark gray, silty with a few chert and quartz pebbles	3	0
Glacial drift:		
5. Clay, sandy, sticky, dark gray (gumbotil)	3	0
4. Sand, yellow, iron stained, clayey	2	6 ±
3. Till, brown, noncalcareous	3	0
2. Silt, yellow, cemented by iron oxide		6 ±
1. Till, brown, and gray, calcareous	3	0
Covered		

Sample B-13 was taken from bed 6 and B-14 from bed 5.

Sample B-19

The exposure occurs in road ditch on north slope of valley of West Weather Creek, cen. E. line, NE. 1/4 NE. 1/4 sec. 1, T. 5 N., R. 8 E., Jasper County, about 1 mile southwest of Bogota. About 3 feet of gumbotil from which sample B-19 was taken outcrops below about 2 feet of soil and other material poorly exposed.

Sample B-20

Two miles west of Groveland and 1/2 mile south of Highway 98, along a stream, NE. cor. NW. 1/4 SE. 1/4 SE. 1/4 sec. 20, T. 25 N., R. 4 W., Peoria County.

	Thickness Ft.	in.
Probably loessial material:		
5. Soil and gray silt	2	0
Glacial drift-Wisconsin:		
4. Clay, sandy, pebbly brown, noncalcareous	1	8
3. Till, calcareous, pebbly	4-5	
Glacial drift-Illinoian:		
2. Gumbotil, gray and brown	2-2½	
1. Till, gray, calcareous	5	0
Covered		

Sample B-20 was taken from bed 2.

RESULTS OF TESTS

The results of tests on the foregoing samples are given below:

Clay mineral composition

The results of clay mineral identifications for Samples B-13, B-14, B-19, and B-20 show that they are all composed of illite, kaolinite, and montmorillonite (?).

Table 5. - Particle size determinations

Sample	Clay fraction -0.002 mm (Per cent)	Silt fraction 0.002 - 0.053 mm (270 mesh) (Per cent)	Sand and pebbles +0.053 mm (270 mesh) (Per cent)
B-14	28.2	23.9	47.9
B-19	42.5	27.5	30.0
B-20	47.6	51.1	1.3

Table 6. - Results of percolation tests a/

Sample	Condition of sample	Height of column (inches)			
		Water-white	Yellow	Orange	Red
B-13	Raw	6/16	1/16	1/16	4/16
B-14	"	6/16	1/16	2/16	2/16
B-19	"	8/16	2/16	1/16	1/16
B-20	"	8/16	1/16	1/16	3/16
Standard fuller's earth b/	"	10/16	2/16	3/16	2/16

a/ Tests made by Mr. Paul Henline, Research Assistant, Analytical Division, of the Geochemical Section, Illinois State Geological Survey, under the supervision of Dr. O. W. Rees.

b/ Standard fuller's earth as furnished by the American Oil Chemists Society.

GUMBOTIL, ITS NATURE AND OCCURRENCE 2/

Gumbotil is derived from glacial till by weathering, and is a gray to brownish-gray clay which is highly plastic when wet and hard and tough when dry. In some places gumbotil contains large amounts of silt, sand, and pebbles but in others may be largely devoid of sand and pebbles.

Gumbotil does not occur on glacial drift as young as the Wisconsin drift but is common on the older drifts - the Illinoian, Kansan, and Nebraskan. It formed under conditions of poor drainage, usually just below the soil layer over broad, flat upland tracts. Subsequent to the formation of the gumbotil valley development took place, dissecting the upland tracts and leaving the gumbotil on the divides.

Following the formation of the Illinoian gumbotil and its erosion, a mantle of wind-blown silt (loess) of varying thickness was deposited on it in southern and western Illinois, producing the present overburden in these areas. Figure 4 shows the distribution of the loess according to thickness in the areas where gumbotil is common. In the area covered by the Wisconsin drift, the Illinoian gumbotil is deeply buried by that drift.

The conversion of till to gumbotil in nature involves oxidation, leaching of carbonates, and chemical decomposition of the silicate materials. Only the most resistant rock and mineral fragments remain and some of these are reduced in size. The base of the gumbotil is commonly denoted by a zone containing bands of yellow or brown iron oxide.

The original till contained large amounts of clay minerals of the illite group, and in general the processes of weathering have tended to remove alkalies, particularly potassium, and to alter the illite minerals to those of the montmorillonite group. These changes took place in varying degrees on the same drift sheet due to variations in weathering conditions and parent material.

The distribution of the Illinoian, as well as the Wisconsin drift, is shown in figure 4.[3/] The thickness of the gumbotil on the Illinoian drift varies commonly from 2 to 3 feet in southern Illinois and from 1 to 3 feet in western Illinois.

SUGGESTIONS REGARDING PROSPECTING

As the clay mineral material in gumbotil is largely responsible for its useful properties, it is desirable that gumbotil as high in clay as possible be discovered. No data are at hand to indicate where especially clayey gumbotil may be found but since the gumbotil results from the weathering of till, those areas wherein the Illinoian till is low in pebbles, sand and silt might be expected to contain the most clayey gumbotil.

It has been previously stated that gumbotil occurs below the broad upland flats of the area of Illinoian glacial drift. These upland flats are therefore the most promising areas for prospecting. Figure 4 indicates those areas wherein the topography is characterized by tabular divides and where occurrences of gumbotil are common. Locally railroad cuts or road cuts in these areas, if not overgrown or slumped, expose gumbotil, or relatively recent stream cutting may reveal gumbotil near the edges of the upland flats. Soil augering or test pitting in the flats themselves are other means of locating deposits.

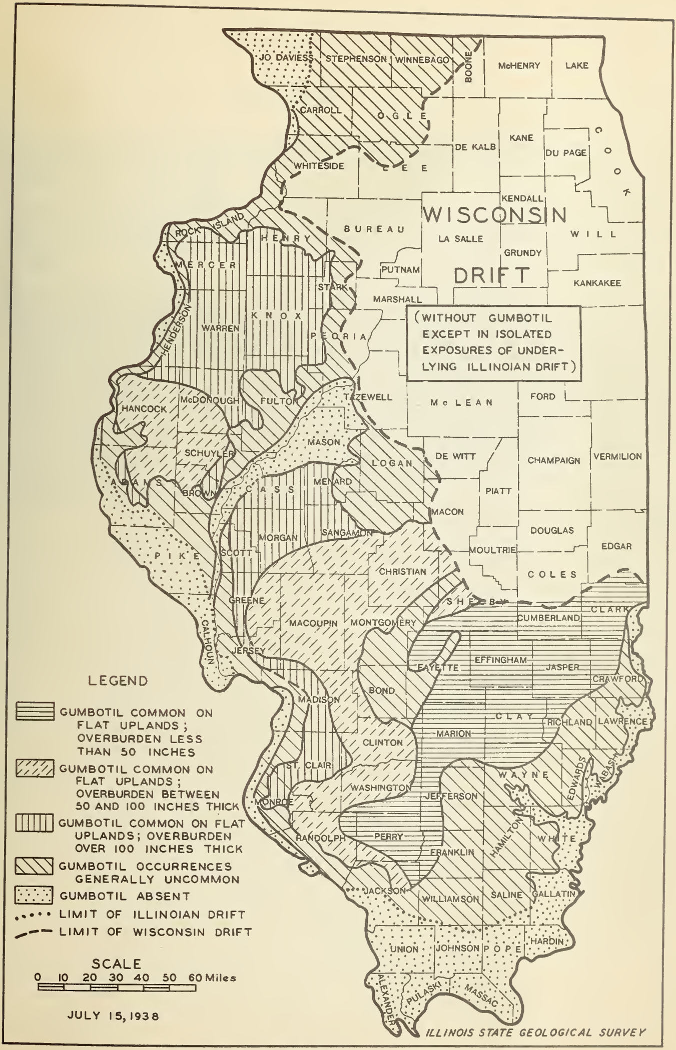

Figure 4. - Generalized map showing distribution of gumbotil and approximate thickness of loess overburden.

REFERENCES

1/ Nutting, P. G., Activation of 3 common types of refinery bleaching clays using water and weak acid: Oil & Gas Jour., Nov. 16, 1933.

2/ For a more detailed discussion of gumbotil see Leighton, M. M., and MacClintock, P., Weathered zones of the drift sheets of Illinois: Ill. Geol. Sur., Rept. Inv. No. 20, 1930.

3/ This figure has been compiled from several sources: Leverett, Frank, The Illinois glacial lobe: U. S. Geol. Survey Mon. 38, 1899; Smith, R. S., Norton, E. A., Winters, E., and Wascher, H., Parent materials, subsoil permeability and surface character of Illinois soils: Univ. Ill., College of Agriculture, Agr. Exp. Sta. and Ext. Ser., July, 1935, map "Parent materials of Illinois soils"; MacClintock, Paul, Recent discoveries of pre-Illinoian drift in southern Illinois: Illinois State Geol. Survey, Rept. Inv. 19, p. 28, 1929; and from unpublished field data of M. M. Leighton and George E. Ekblaw of the State Geological Survey.